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A STRUCTURAL AND LITHOLOGIC MODEL FOR THE FORMATION GOLD BEARING QUARTZ BRECCIAS AT GORDON LAKE, N.W.T.

Open File Report

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by T. Stokes, M. Zentilli and N. Culshaw

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SUMMARY

Structural and lithologic mapping within the Burwash metaturbidite Formation of the Archean Yellowknife Supergroup at the southern end of Gordon Lake (lat. 62° 54'N and long 113° 15'W), N.W.T. has identified five breccia types. Of these the most economically interesting, with respect to tonnage potential and gold mineralization, is the stratabound siltstone hosted type; as found at Kidney Pond to the north of Knight Bay. The stratabound breccias, formed by late asymmetrical tightening of the Gordon lake refold and bedding parallel slip mechanisms, are concentrated within the central region of the refold. These breccia are associated with the development of a distinct crenulation cleavage and occur within a particular lithologic interval of thin bedded alternating wackes and carbonaceous siltstones.

Exploration criteria for the location of other similar gold bearing, breccia zones include the recognition of regions of structurally late (post-peak metamorphism) deformation and favourable lithologies of alternating, thin bedded wackes and siltstones (preferably carbon rich).

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1. INTRODUCTION

Send to Dr. N. Culshaw

This report fulfills the requirements of a 1988-89 Mineral Development Agreement between Dr Zentilli, Geology Department, Dalhousie University, Halifax, Nova Scotia and the Government of the Northwest Territories. The purpose of this second contract was to continue the investigation into the occurence of gold bearing quartz-breccia systems found at Knight Bay, South Gordon Lake (lat. 62° 54'N and long. 113° 15'W), and to further refine and test the regionally predictive model suggested by Stokes et al. (1988a, 1988b, 1989a, 1989b and 1989c). This report summarizes the field data collected in the summer of 1989 and specifically focusses on the stratabound style of quartz-breccia found at Kidney Pond and other localities within the southern Gordon Lake area.

The gold bearing quartz-breccias at Gordon Lake lie within the Burwash metaturbidite Formation of the Yellowknife Basin, the most southerly metasedimentary terrane of the Archean Slave Province (Figure 1). The Basin is flanked to the east by the Cameron River volcanic belt and to the south-west by the Yellowknife volcanic belt. The Yellowknife Supergroup in part overlies granite-gneiss basement and is intruded by later granites that influence the regional metamorphic pattern.

For further details on Yellowknife Basin Geology see Henderson (1985); for Burwash Formation stratigraphy Henderson (1975, 1987); for regional metamorphism, Kamineni et al.(1979), Thompson (1978) and Ramsay et al. (1977); for structure, Drury (1977), Fyson and Helmstaedt (1987) and Fyson (1975, 1980, 1981, 1982, 1984); and for previous work on gold-quartz veins, Padgham (1984, 1986), and Fyson (1986).

2. GORDON LAKE GEOLOGY

2.1. Structure

The results of the 1988 field work generally confirmed the structural model developed by Stokes et al. (1988a and 1988b) for the formation of the Gordon lake refold and the gold bearing, quartz-breccia zones. The model suggested that during late asymmetrical tightening of the Gordon Lake refold late metamorphic fluids were focussed into the centre region of the refold. The late tightening induced dextral bedding parallel slip in the centre of the refold and resulted in the formation of a crenulation cleavage and quartz filled dilational breccia zones. This structural model has now been modified and refined by the field work of 1988 (see Map 89-1).

The refold, based on cleavage and bedding measurements, was divided into four structural domains (Figure 2). The

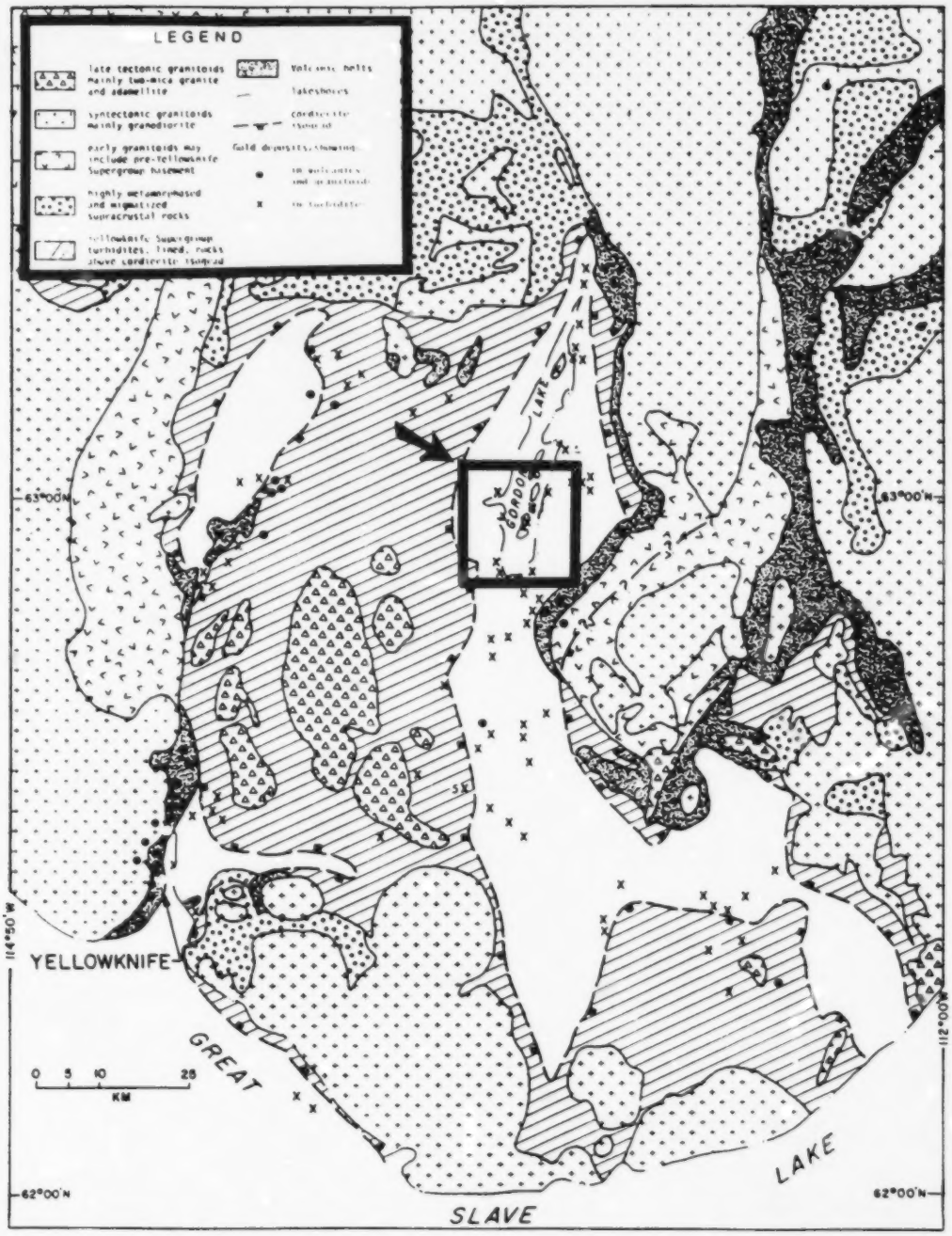

Figure 1. Geology and gold deposits of the Yellowknife Basin with the location of study field area (arrowed) at Gordon Lake,(after Padgham, 1986).

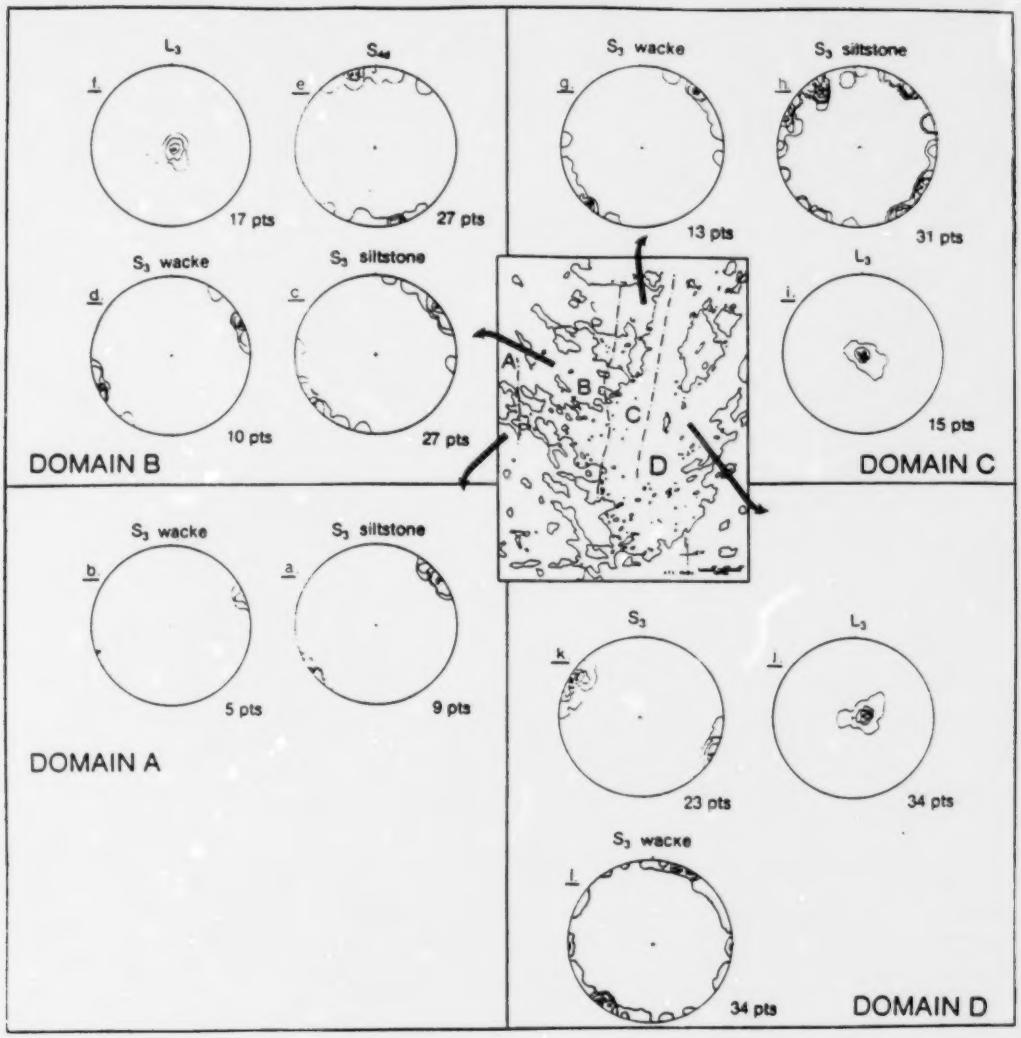

Figure 2. Structural Data of the Gordon lake refold. Lower hemisphere, equal area projections. Domain A; a) S3-siltstone contoured at 11, 19, 35 and 51%/unit area, b) S3-wacke contoured at 20, 48 and 90%/unit area. Domain B; c) S3-siltstone contoured at 4, 14, 44 and 54%/unit area, d) S3-wacke contoured at 10, 30, 40, 50 and 60%/unit area, e) S4d contoured at 4, 24, 34 and 44%/unit area, f) L3 contoured at 6, 26, 56 and 76%/unit area. Domain C; g) S3-wacke contoured at 12, 23 and 38%/unit area, h) S3-siltstone contoured at 3, 6, 9, 12 and 15%/unit area, i) L3 contoured at 7, 34 and 51%/unit area. Domain D; j) L3 contoured at 3, 33, 53, 63, and 73%/unit area, k) S3 contoured at 4, 14, 24 and 34%/unit area, l) S3-wacke contoured at 7, 11, 15, 19, 23, and 27%/unit area.

'regional ' cleavage (S3) in the wackes appears to transect the fold, whereas S3 in the siltstones varies in strike from NW to NNE from west to east across the refold. However, the S3 wacke cleavage also indicates some evidence of rotation and varies in strike from an average 340° on the west limb to 300° on the east limb. Within the central domain of the refold further evidence (in addition to the S4 crenulation) was found for intense dextral bedding parallel slip. This included offset quartz veins (by 0.1-2m along bedding) and rotated echelon veins (see Type 7 in Section 3) . Kinking of S3 in wackes was also found within the central portion of the refold (Figure 3) and forms possible conjugate sets.

The change in strike (by 40° anti-clockwise) of the S3 wacke cleavage, from west to east across the refold, is probably the result of the east limb rotation during D4 asymmetrical tightening; where the S3 wacke cleavage behaves as a passive marker. However, a greater variation in S3 siltstone cleavage strike is seen; from a relatively 'undisturbed' (with respect to D4) S3 region on the west limb, to a central region of complex cleavage orientations, and finally to the east limb which records most of D4. Therefore the S3 siltstone cleavage records the all finite strain imposed by D4. In the centre of the refold the dextral bedding slip, from the refold tightening and east limb rotation, resulted in a herring-bone cleavage pattern. Here two distinct cleavage types are recognised; the S3 regional cleavage and a crenulation cleavage. The dextral bedding parallel slip displaced earlier quartz veins that crosscut bedding, produced kinking of S3 in wackes, rotation of veins and more importantly created late dilational opening with the formation of stratabound siltstone hosted brecciation zones (see Section 3.3.)

2.2. Stratigraphy

In the southern Gordon Lake region a change in regional lithology is present, previously recognised by Henderson (1941) and Padgham (1986). Mapping of gross lithology types during 1987 and 1988 (Figure 4) outlined a curved, southward tapering wedge of siltstone sequences. This wedge is surrounded to the west, south and east by fine to medium grained wacke dominated sequences. The siltstone wedge curves into the bays along the south-western edge of Gordon Lake including Knight Bay and the Lynx Inlet. Along this south-western shore 0.1-1.5m sequences of laminated coarse and fine siltstones (Figure 5) were mapped. These alternating siltstone layers probably resulted from bottom current winnowing processes in a relatively quiet distal turbidite environment (Pickering et al. (1986), and possibly indicate a regional stratigraphic transition from rapid turbidite flow deposition to quieter pelagic sedimentation.

Figure 3. D4 related kinking (K) of S3 in wacke beds. Dashed line parallel bedding.

Figure 5. Laminated sequence of interbedded fine (dark beds) and coarse siltstones (light beds) found along western edge of siltstone-wacke regional lithological boundary.

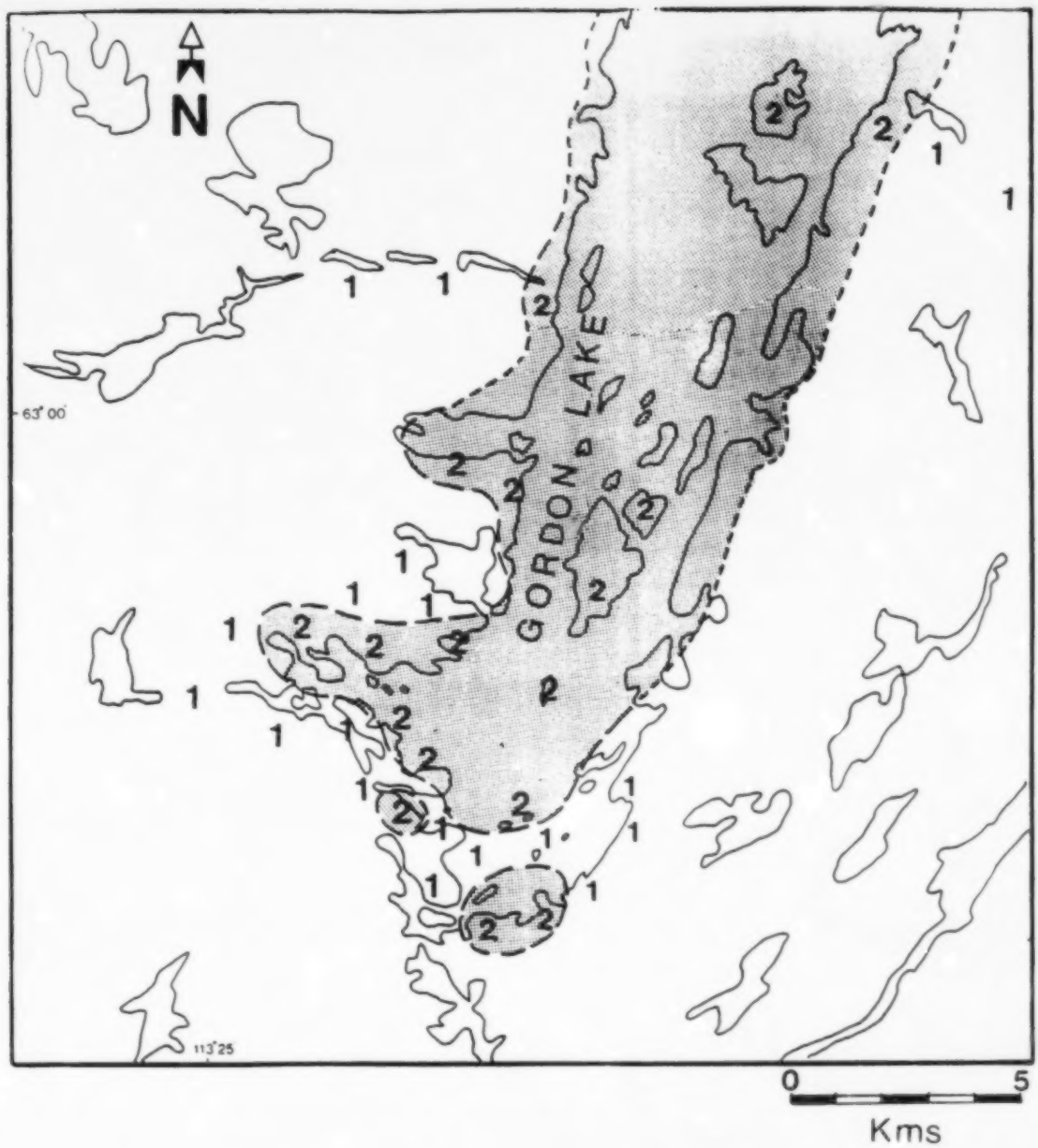

Figure 4. Regional lithology variation at Gordon lake. Locations indicate groups of outcrops: 1 - medium to fine grained wacke dominated area with less than 30% siltstones and 2 - stippled area of greater than 30% and upto 90% coarse to fine siltstones.

2.3. Metamorphism

Gordon Lake lies within a region of low greenschist grade metamorphism that is defined by the absence of cordierite. Within the region both biotite and cordierite are associated with peak metamorphic conditions and closely related to S3 development. Previous mapping of metamorphism within the region (Henderson, 1941 and Henderson, 1985) has located the position of a mapped cordierite isograd (Figure 6). Present mapping and examination of thin sections has defined a region devoid of biotite or cordierite porphyoblast development on the refold's east limb, also recognised by Henderson (1943). This is probably a result of either a lower grade of metamorphism, greater retrograde conditions or an unsuitable bulk rock chemistry. Interestingly, a noticeable increase in metamorphic grade is found surrounding the Kidney Pond area with the development of fine mm scale cordierite porphyoblasts, particularly in the blacker siltstones. This is possible indicative of a localized thermal high around the mineralized zone. Another possible localized zone of cordierite is found around the '31 Vein' on Zenith Island.

As D4 post dates peak-metamorphism conditions a probable change in metaturbidite rheology occurs; from more ductile in D3 to more brittle regime in D4. Therefore improving conditions for the formation of dilational zones, fracturing and brecciation.

3. GORDON LAKE VEIN AND BRECCIA TYPES

Six of the seven morphological vein types recognised were discussed by Stokes et al. (1988a) and included:

Vein Type 1 - Bedding parallel veins.
Vein Type 2 - D3 deformed, wacke hosted, echelon and reticulate veins.
Vein Type 3 - Siltstone hosted, S3 parallel veins.
Vein Type 4 - Stretched/boudinaged 'east limb' veins
Vein Type 5 - Sub-horizontal veins.
Vein Type 6 - S4d parallel veins.
Vein Type 7 - Rotated echelon veins.

Type 7 veins occurs in alternating siltstone/wacke lithologies and appear confined to the central portion of the refold. The tips of the veins lie sub-parallel to S3 in the wackes, while the the central body of the vein occurs within the siltstones and is at an angle of 20-120o anti-clockwise to the vein tips, (Figure 7). Similar types of veins were reported by Henderson (1983) across the early folds within the Meguma turbidite

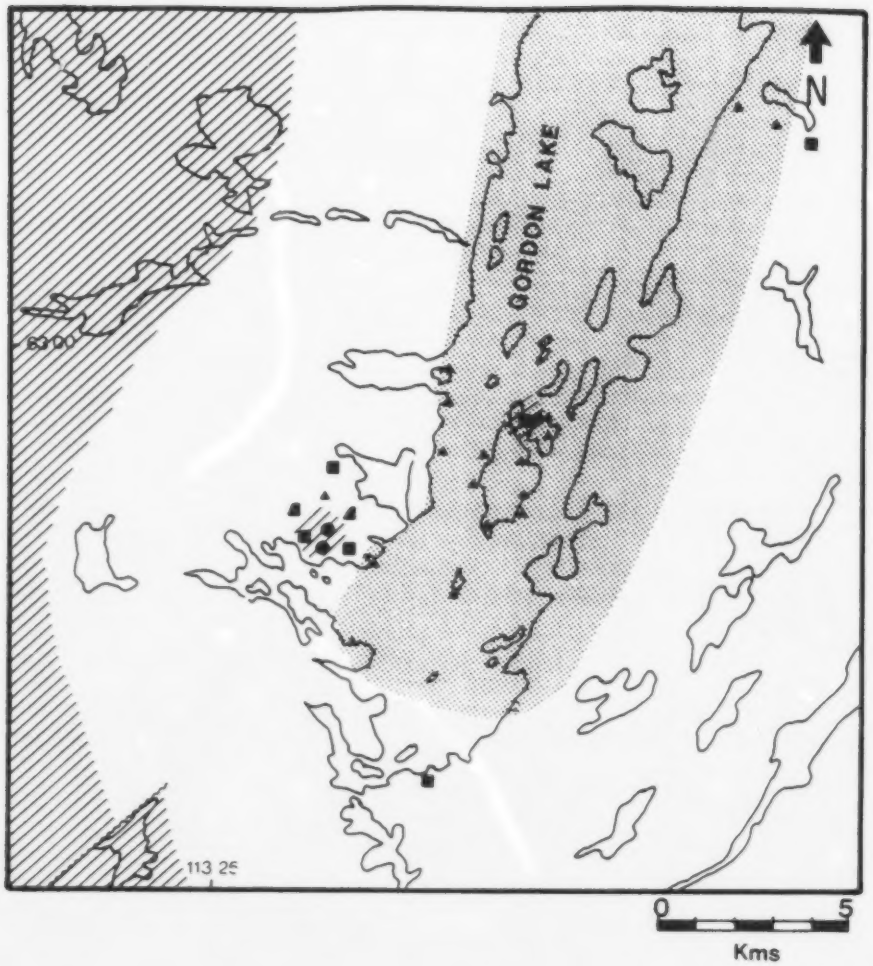

Figure 6. Regional metamorphic pattern at Gordon Lake. Cross-hatch indicates limits of cordierite boundary (adapted from Henderson (1941), stippled area indicates a biotite and cordierite free region. Thin section samples located by square (biotite present), a triangle (biotite free) and a circle (cordierite present).

Figure 7. Siltstone hosted echelon veins rotated by dextral bedding parallel slip (half-arrows). S0 marks cuspate bedding contact between wacke (W) and black siltstone (BS), T the unrotated vein tip and R the rotated main vein body.

Figure 9. Breccia Type I - Sub-parallel to F1 fold axial trace (thick dashed line marks anticline axial trace). Note bedding offset along fold hinge (curved thin dashed line), vein swarms parallel F1 axial trace and D3 deformation of side veinlets (arrowed).

terrane of Nova Scotia, these indicated opposing senses of vein rotation due to flexural-slip folding mechanisms. At Gordon Lake, however, there is no apparent change in vein tip/body rotation across the axes of early F1 folds, most formed by dextral bedding parallel slip. These veins are morphological similar to Type 3 but probably underwent subsequent D4 deformation. Further east complete vein rotation probably resulted in the formation of the Type 4 boudinaged east limb veins.

The quartz-breccias types found at Gordon Lake are morphologically distinct from the vein types, but are related both spatially and temporally in their distribution. The quartz-breccias are characterized by: 1) 'jig-saw' fitting clasts in a matrix of both grey/white quartz and feldspar, 2) minor clast alteration and rotation, and 3) high matrix/clast ratios. However, the breccia types vary in their overall dimensions, structural setting, distribution and host lithology, and are therefore divisible into five morphological types (Figure 8):

Breccia Type I - Sub-parallel F1 fold axial traces.
Breccia Type II - Sub-parallel F3 fold axial traces.
Breccia Type III - Stratabound siltstone S4d associated.
Breccia Type IV - Wacke hosted breccias.
Breccia Type V - Boudinaged east limb breccias.

3.1. Breccia Type I - Sub-parallel F1 fold axial trace

Quartz veining and brecciation is found as 'pinch and swell' zones along the axial traces of F1 isoclinal folds. These were recognised as a distinct structural vein type by Brophy (1986) and characterize Dome Lake and other vein systems within the Yellowknife Basin. The breccia zones are characterized by complex vein swarms that run sub-parallel to the F1 axial traces (Figure 9) and in some places appear associated with offsets along fold hinges. They are commonly 1-5m wide and are distributed sporadically along F1 axial traces. The breccia zones examined near Kidney Pond occur in siltstone dominated lithologies, and consist predominately of white quartz and chlorite. Side veins along the breccia systems commonly exhibits folding and deformation by D3.

3.2. Breccia Type II - Sub-parallel F3 fold axial traces.

Type II breccias and vein swarms are confined to F3 fold axial trace and are smaller in size than Breccia Type I. These veins appear either as parallel swarms or echelon systems associated with offsets along F3 axial traces (Figure 10). In some place these vein swarms coalesce into zones of intense brecciation.

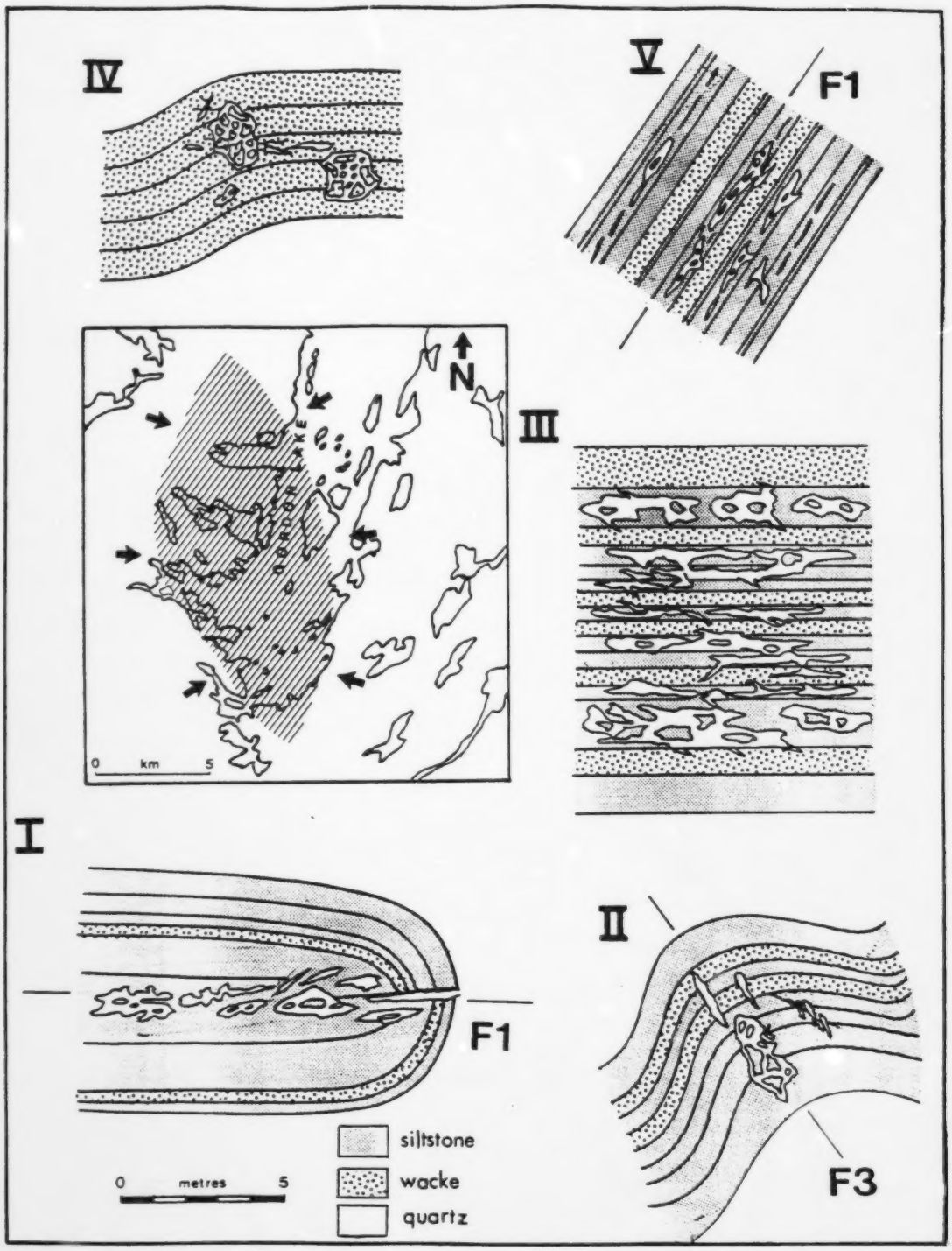

Figure 8. Schematic figures of breccia types I, II, III, IV, and V (for explanation see text). Types III and IV are confined to the cross-hatched region of suggested fluid focussing at Gordon Lake. Type V is confined to the eastern edge of this cross-hatched region. While types I and II are regional distributed throughout the Yellowknife basin.

Figure 10. Breccia Type II - Sub-parallel to F3 fold axial traces (thick dashed lines). Note bedding (thin dashed line) offsets (wavy lines) with echelon vein formation and breccia zone (arrowed).

Figure 11a. Breccia Type III - Stratabound Siltstone Hosted. Rotated echelon veins (R) in black siltstone (BS) unit, unrotated tips (T) in fine wacke (W) unit.

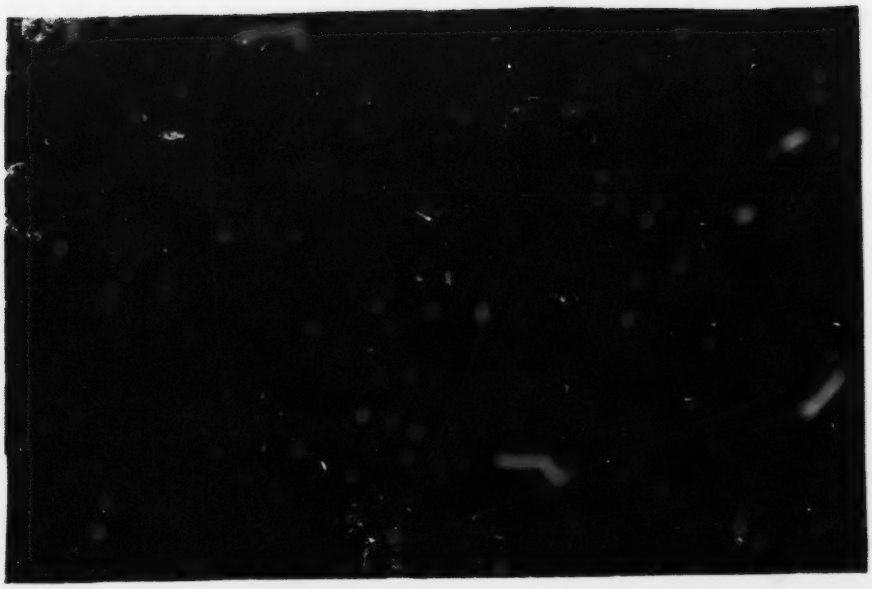

Figure 11b. Breccia Type III - Stratabound Siltstone Hosted. Rotated echelon veins with initiation of wallrock fragment isolation and brecciation (arrowed).

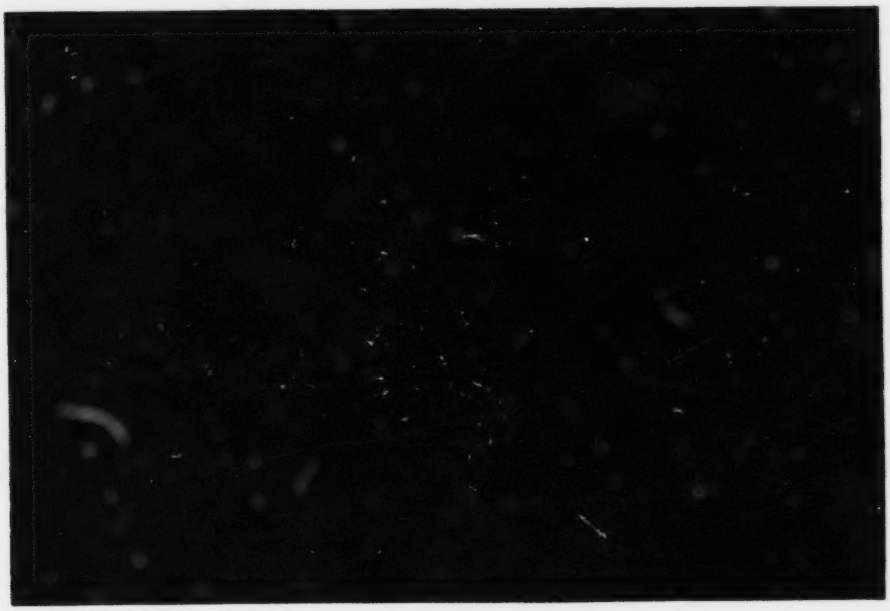

Figure 11c. Breccia Type III - Stratabound Siltstone Hosted. Completely brecciated black siltstone unit with quartz matrix. Note angular character of fragments with feldspar rims (arrowed).

3.3. Breccia Type III - Stratabound Siltstone Hosted Breccias.

This breccia type characterizes the 'Kidney Pond' Zone 1 (described in Section 4) and are confined to the central portion of the refold. As Zone 1 is poorly exposed other similar zones were examined to observe breccia/structural relationships. These breccias occur in siltstone dominated lithologies (commonly black and carbonaceous) and are situated away from F1 fold axial traces and hinges. The best exposure of this type of breccia is on the south shore of a bay south of Knight Bay. Here, the stratabound breccia is found in various stages of development and has a strike length of 75-100m. Veins parallel the S3 cleavage appear rotated in siltstone beds and are similar to the Vein Type 7 (Figure 11a). In some cases this rotation (dominately dextral) has induced brecciation (Figures 11b and 11c) and developed a crenulation cleavage. The stratabound breccia zones are not completely confined to siltstone beds but appear to 'jump' from one bed to another, fracturing the intervening wacke bed. The matrix material is composed of grey quartz which surrounds the feldspar rimmed siltstone fragments.

3.4. Breccia Type IV - Wacke Hosted Breccias.

This breccia type occurs as pods or 'blow outs' within wacke-dominated lithologies (Figure 12), such as to the west of the Lynx inlet. Mineralogically these breccias are similar to Type III, but do not appear confined by any obvious structures other than minor flexes or warps in bedding. The main characteristic of this type of breccia is their completely irregular character and shallow depth extent as testified by previous drilling and trenching of these zones (Caelles, 1984).

3.5. Breccia Type V - East Limb Breccias

These breccias are morphologically similar to Vein Type 4 in that they are boudinaged (both vertically and horizontally) and are sub-parallel to the east limb S3 cleavage and bedding. They are characterized by upto 2m wide zones of quartz material in which siltstone fragments with rotated cleavages are found (Figure 13). These zones are closely spaced and in some cases indistinguishable from the Type 4 vein swarms.

4. KIDNEY POND ZONE 1 QUARTZ-BRECCIA

4.1 Structural and Lithologic Setting

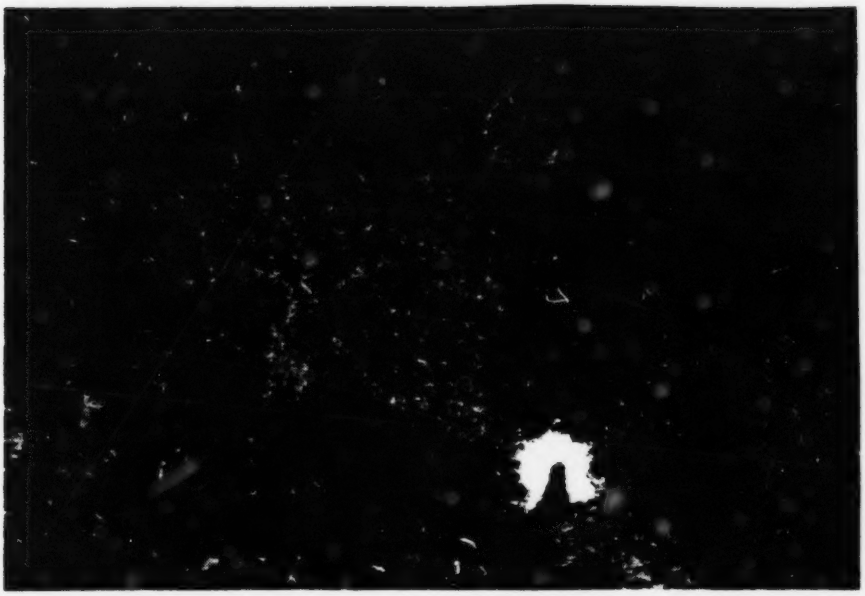

Figure 12. Breccia Type IV - Wacke Hosted. Note angular character of wallrock fragments and jig-saw like clast morphology (arrowed).

Figure 13. Breccia Type V - East Limb Breccia. Note slight clast rotation (arrowed)

Within the Kidney Pond area, explored extensively by Giant Bay Mines Ltd., Vancouver 1984-87, are four major quartz-breccia zones, Zones 1, 2, 3 and 4 (Figure 14). Of these the most economically important is the Kidney Pond Zone 1 quartz-breccia which is located on the north limb of a vertically plunging, E-W trending asymmetric F1 anticline. The breccia zone has poor surface exposure and lies almost entirely below Kidney Pond. Drilling and an access ramp exposed the breccia zone and delineated its dimensions (260m in strike length, a width of 5-30m and a depth of at least 180m) and stratabound character (Caelles, 1984). The underground workings have been closed and flooded since 1987. Mapping of outcrop to the north of Zone 1 (Figure 15) indicates traceable wacke and siltstone dominated sequences with different deformation characteristics; the wackes flex and bend around the siltstones - which are commonly tightly folded and faulted. Underground mapping of Zone 1 in 1986 (Figure 16) and mapping of surface outcrop to the north confirmed the general stratabound character of the breccia. However, the south-east end of the breccia zone appears to transgress bedding. This is probably explained the 'jumping' effect of the brecciation processes across lithologies, where siltstone beds are completely brecciated and intervening wacke beds only slightly veined.

A stratigraphic section was completed, using both surface exposure and drill core, from the ESE-WNW trending F1 anticline northwards across the Zones 1 and 2 breccias (Figure 17). This indicated four facies associations: 1) a thick bedded wacke sequence; 2) a thick-medium bedded sequence of alternating wackes and siltstones; 3) a thin bedded bedded sequence of alternating wackes and siltstones and 4) a thin and laminated sequence of siltstones. From this cursory analysis it appears that the Zone 1 and 2 breccias lie within and along the contact between facies association 3) and 4). In addition the character of the siltstones appears darker and is probably the result of a higher carbon content. This carbonaceous material possibly plays a role in the fracturing process and deposition of sulphides and gold.

4.2. Breccia Paragenesis and Mineralogy

From an examination of surface and underground drill core of the Kidney Pond Zone 1 breccia it was possible to develop a paragenetic sequence of structural, mineralogical and mineralization events. The quartz-brecciation is invariably confined to black siltstones, with only minor quartz veining in adjacent wacke beds. Two distinct phases of breccia were found within the Kidney Pond Zone 1 and include: 1) a fine micro-brecciation with mm-cm scale equi-dimensional fragments of unaltered black siltstone set in a matrix of white K rich feldspar (commonly sericitized), plagioclase and associated coarse biotite and 2)

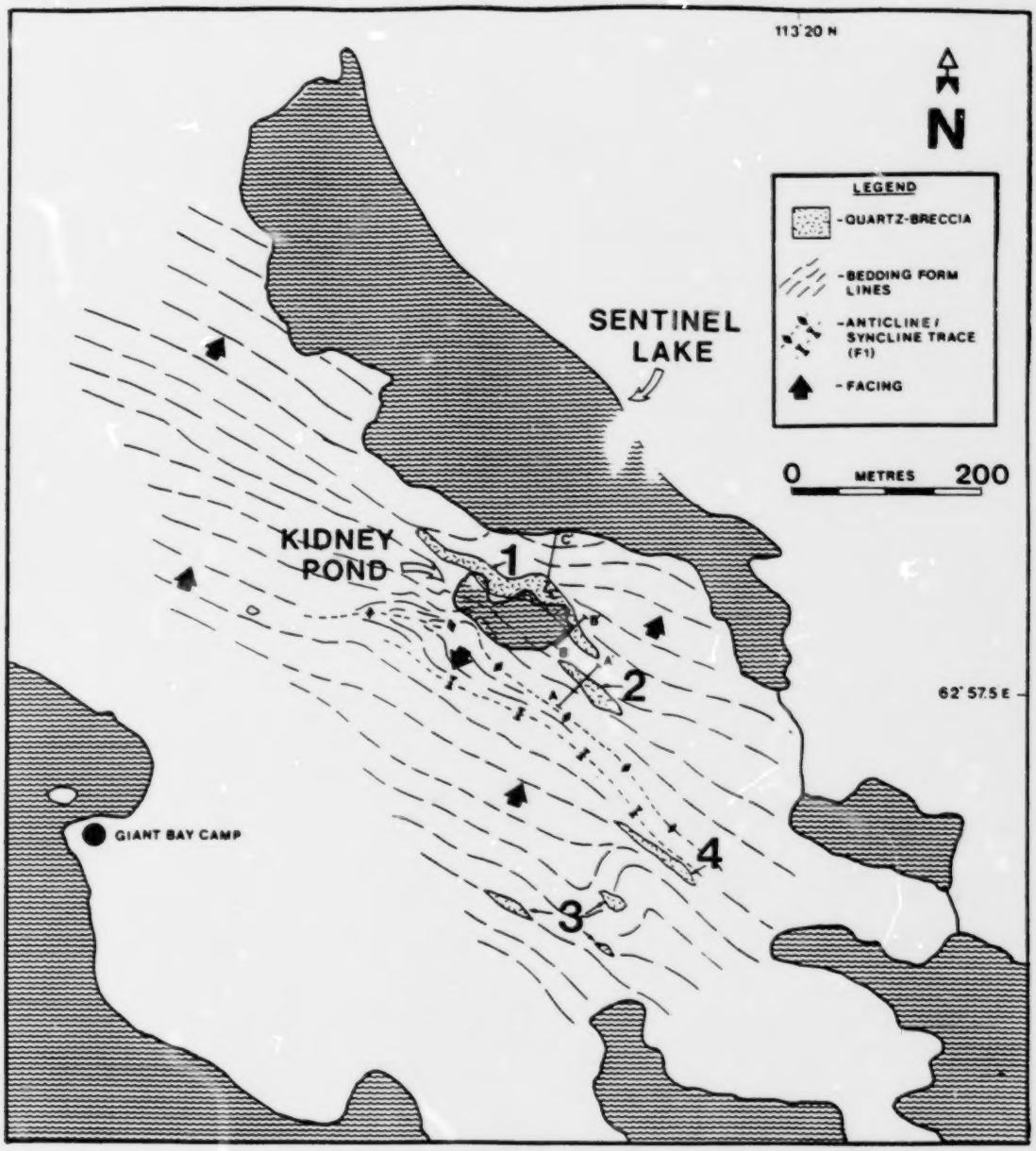

Figure 14. Structural location of Breccia Zones 1, 2, 3 and 4 at Kidney Pond. A-A', B-B' and C-C' approximately locate stratagraphical section (Figure 17) across Zones 1 and 2.

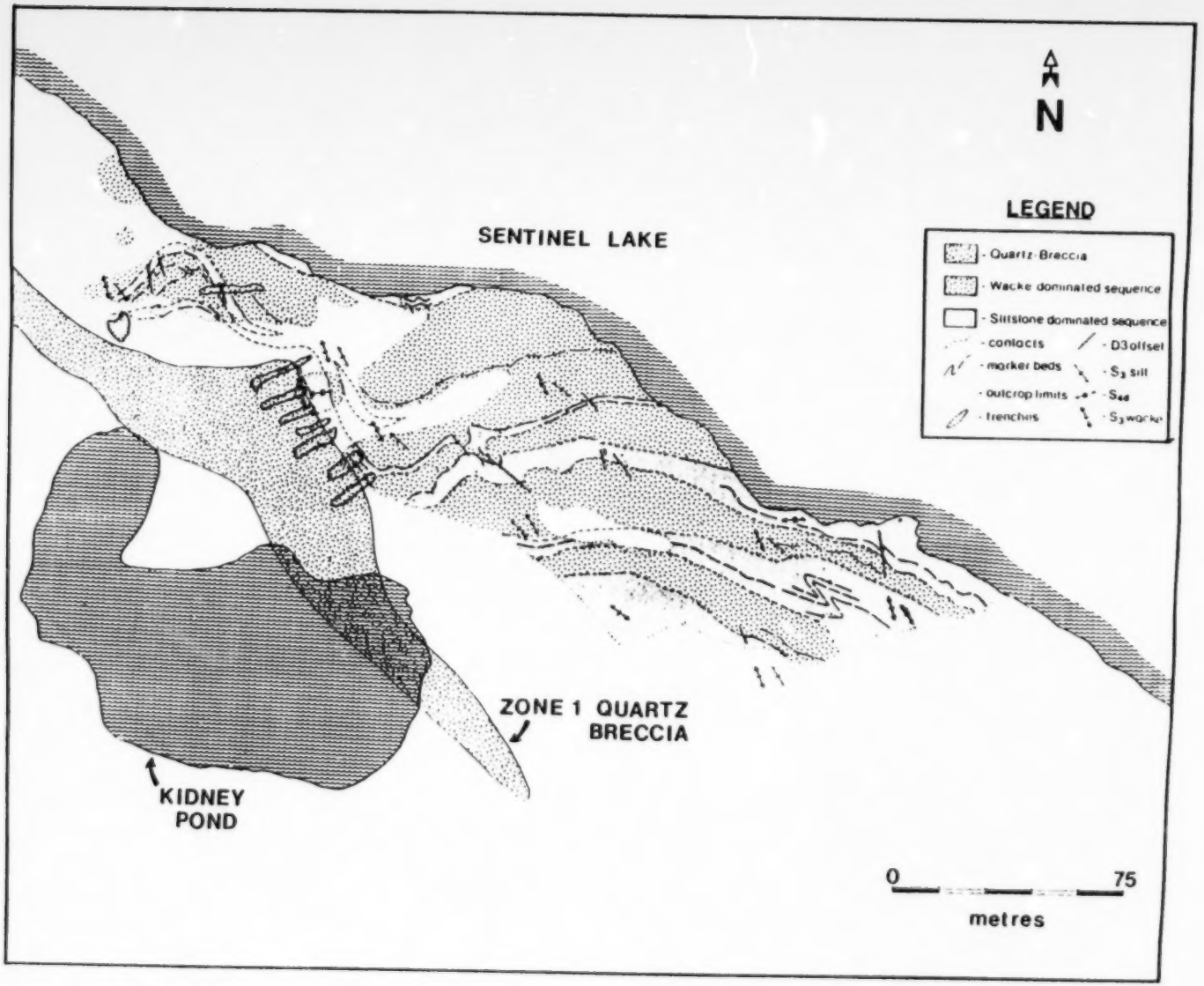

Figure 15. Surface exposure to north-east of Kidney Pond Zone 1. Note, as in underground map stratabound character of zone to west and slight crosscutting to east. Also note the different deformational styles between wacke and siltstone dominated sequences.

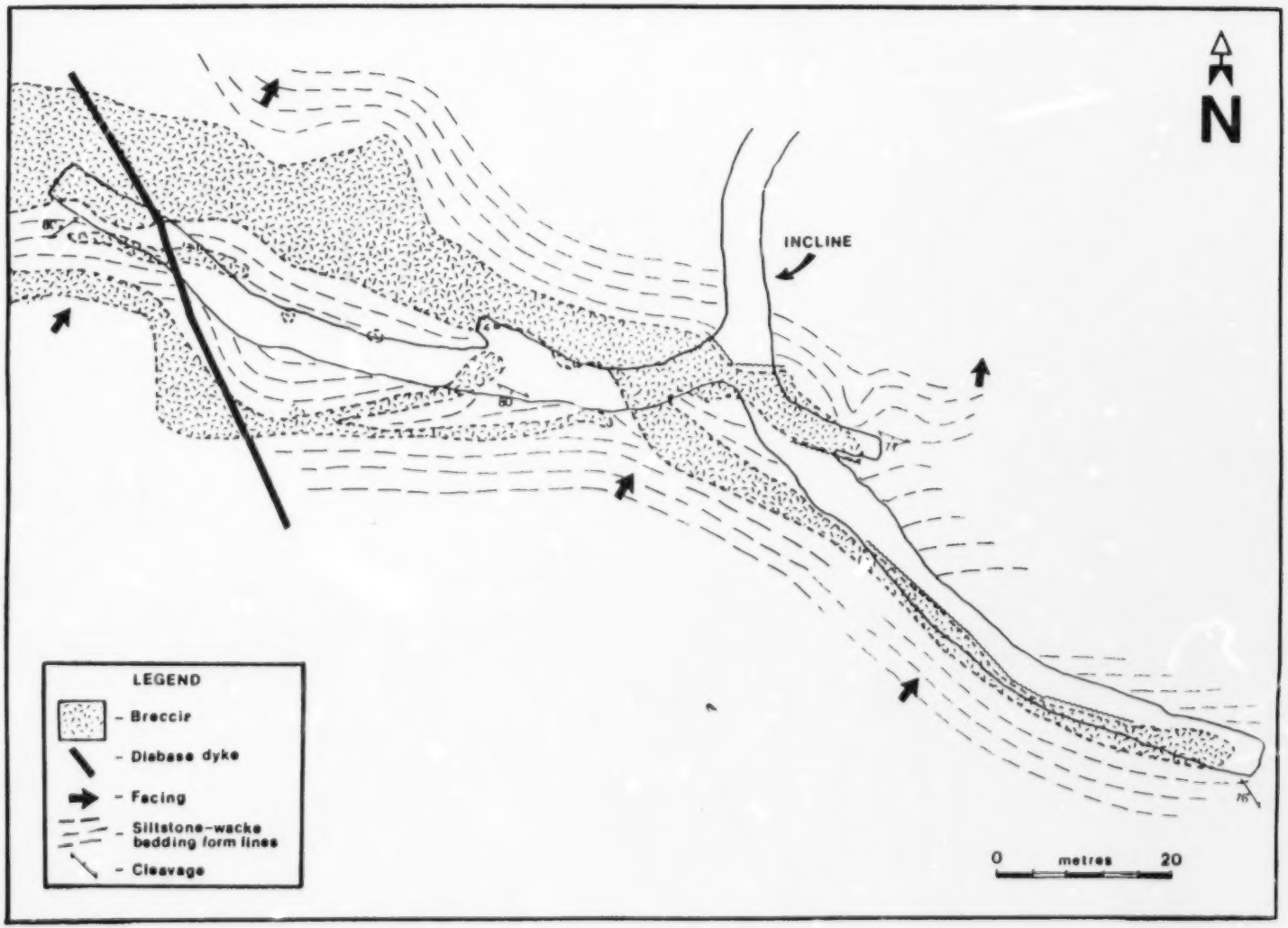

Figure 16. Underground structural map of the south-east end of Zone 1 breccia at Kidney Pond (see Figure 14). Note stratabound character of zone to west of map and slight cross-cutting to east.

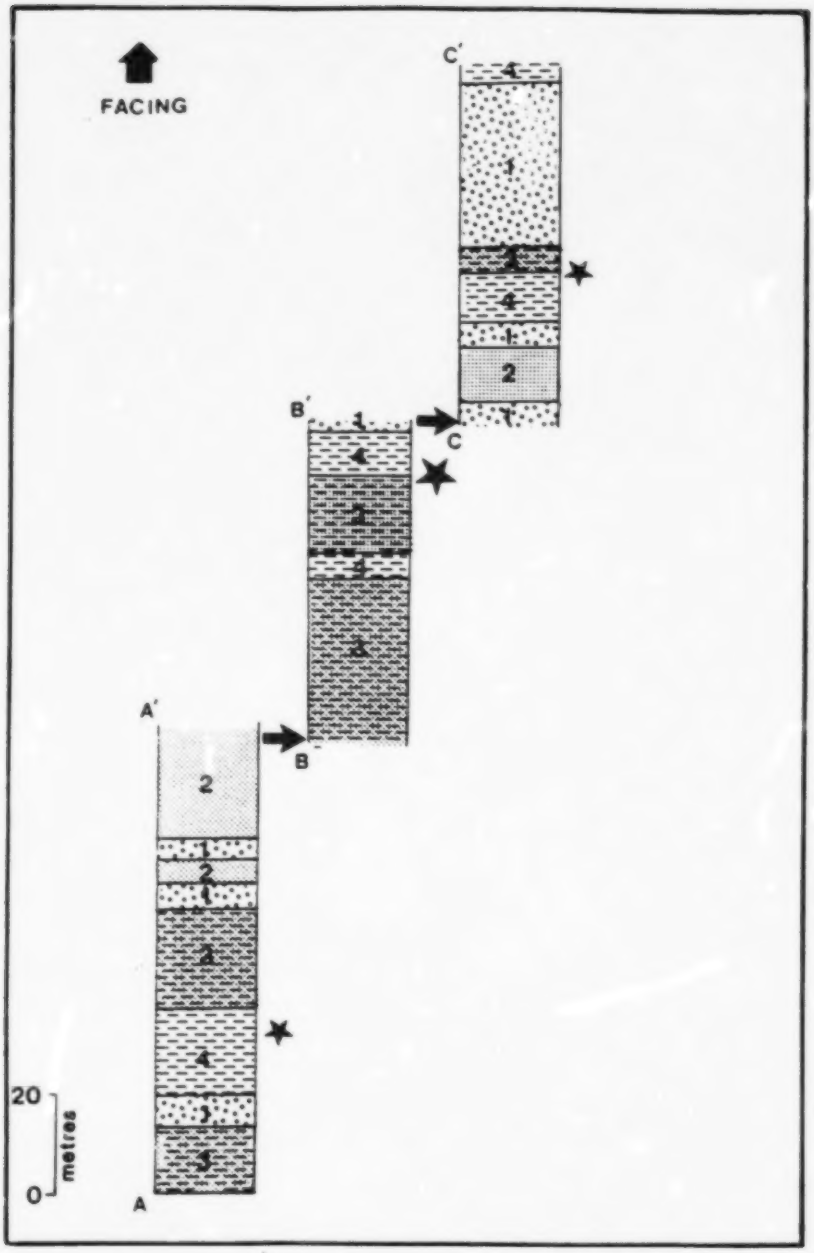

Figure 17. Stratigraphic section across Zone 1 and Zone 2 breccia. Stars locate approximate zones of quartz-brecciation. 1 - Thick to very thick bedded, medium-fine grained wackes with <10% siltstones. 2 - Medium to thick bedded, medium to fine grained wackes and coarse to fine siltstones. Wacke/Siltstone ratio of approximately 60/40. 3 - Alternating thin to medium bedded, fine wackes and coarse to fine siltstone. Wacke/siltstone ratio of 40/60. 4 - Thin to medium bedded, coarse to fine siltstones <10% wackes. Location of stratigraphic section found on Figure 14.

a latter 'flooding' of grey quartz with secondary brecciation along the S3 cleavage resulting in cm-dm scale elongated wallrock fragments. These fragments are rimmed by biotite and chlorite alteration. The grey quartz matrix shows undulatory extinction and is commonly recrystallized around grain boundaries. The grey quartz material accounts for 75-85% of the breccia matrix and appears closely associated with the sulphide mineralization.

Approximately 20% of the black siltstone is crenulated by S4, as well as some sections of the K feldspar/grey quartz breccia and sulphide mineralization. Late veins of pink feldspar (adularia?) and calcite/carbonate infill brittle fracturing across the breccia and crenulated siltstone. Epidote and possibly tourmaline veinlets are also found.

4.3. Sulphide Mineralization and Gol

Within the breccia, sulphide mineralization includes, in order of decreasing abundance: arsenopyrite, pyrrohotite, pyrite, chalcopyrite, galena and gold. Two types of arsenopyrite were found; one as large coarse crystals disseminated in the black siltstones (commonly augened by the S3 cleavage), and the other as (latter) acicular arsenopyrite veinlets. Pyrrhotite (commonly exhibiting pyrite exsolution) appears as veinlets and disseminated within the black siltstone. Both chalcopyrite and galena are minor sulphides associated with the late pyrrhotite and arsenopyrite phases.

Visible gold is found within the grey quartz phase (and was reported by Caelles (1985) to be found in 14 of 39 surface holes drilled on the zone. However coarse gold (0.2 to 6mm) is not common and most gold grades come from material devoid of visible gold. Gold appears in part associated with the late sulphide phases of chalcopyrite and galena.

4.4. Breccia Fluid Inclusion and Geochemical Data

Fluid inclusion analysis of vein types and breccias is difficult due to considerable recrystallization, but can still give some qualitative estimates of fluid character and composition. Homogenization temperatures within the breccia material indicate a range of values from 150-250°C for fracture related inclusions (distinctly secondary) and 250-330°C for non-fracture (secondary or possibly primary) inclusions. Freezing runs indicated average ice-melting temperatures and eutectic temperatures of approximately -45°C and -23°C respectively, indicating the possible presence of Ca or K salts rather than a highly NaCl dominated fluid. No visible CO_2 or clathrates were recognized but are nevertheless suspected as indicated by fluid

inclusion work of English (1980) and Swatton (1987) elsewhere.

Geochemistry of turbidite gold deposits within the region is limited to a study initiated by Brophy (1986) which indicated the possibility of a considerable geochemical halo around the Kidney Pond Zone 1 breccia. He also attempted to discrimate between background and anomalous gold/arsenic values in siltstone and wacke lithologies.

5. BRECCIA FORMING MECHANISMS

5.1. Early Brecciation

The earliest phases of brecciation (probably regional in distribution) appear related to the axial traces of F1 and F3 folds and probably formed during late stages of their respective development and tightening. Both fold types indicate evidence of offsets along their axial trace that enhanced the dilation and brecciation. The F1 fold tightening was also probably aided by the development of the D3 vertical stretch. Possible models for the early breccia formation can be based on multi-layer deformation mechanisms of limb thrusting and buckle folding in fold hinges as suggested by Ramsay and Huber (1983 and 1986).

5.2. Refold Fluid Focussing and Brecciation

The model suggests that regional focussing of late metamorphic fluid towards the central portion of the Gordon lake refold was associated with late D4 asymmetrical tightening of the refold's eastern limb (Figure 18). Fluid focussing in anticlines with shallow plunges is common to oil accumulation and trapping. However at Gordon Lake the refold was vertically plunging during D3 and D4. Fluids produced during the D4 event were probably trapped within the central siltstone wedge (surrounded in by the more impervious meta-wacke terrane), and resulted in a syn-deformational region of abnormally high fluid pressure concentrated in the centre of the refold. Continued refold tightening accompanied by fracturing within regions of structural weakness (flexes and earlier anisotropies) and suitable lithology created brecciation and dilational openings. These were instaneously filled with any available metamorphic fluid formed during the D4 deformational event.

5.3. Late Brecciation Mechanisms

The stratabound siltstone and wacke hosted breccias, appear spatially confined to the central part of the refold, and are the result of D4 asymmetrical tightening and hinge

migration of the refold. Within the central portion of the refold the D4 strain was inhomogenously partitioned between different lithological packages. The greatest strain probably concentrated in regions of thinly bedded, alternating black (carbonaceous) siltstones and wackes. Within these regions increased bedding parallel slip (dominantly dextral) induced echelon fracturing in the S3 cleaved black siltstones with the rotation and overprinting of new echelon veins (Figure 18). Continued bedding parallel slip and preferentially increased fluid pressures within the black siltstones created the apparently 'stratabound' brecciation. Concurrent and subsequent rapid decompression probably led to the precipitation of quartz and sulphides. The carbonaceous material possibly assisted the fracturing and bedding parallel slip mechanisms, and also help in the scavenging and concentration of any available gold within the system.

In wacke dominated areas (such as to the west of the Lynx Inlet) within the centre of the Gordon Lake refold structure focussing of late metamorphic fluids and the poor impermeability of the meta-wackes produced 'pockets' of anomalously high fluid pressures. These resulted sporadic breccia 'blow outs' that have little to no structural control and are limited both areally and at depth. However, late buckling and flexing of wacke packages might have localized zones of brecciation.

The late brecciation is the result of fluid foccusing of late metamorphic fluids into areas that have undergone a post-metamorphic, predominately dextral, bedding parallel slip (Figure 19). Breccia distribution is therefore controlled by this late stuctural dilation event.

6. CONCLUSIONS

1. Five morphological types of quartz-brecciation occur within the South Gordon Lake region. Of these at least two types (the stratabound and wacke hosted) are the result of the focussing of late metamorphic fluids and are confined to the central region of the refold.

2. The stratabound Kidney Pond quartz-breccia type appears the most economically favourable due to its tonnage potential, and is hosted within a lithological facies association of thinly bedded, alternating black siltstones and wackes.

3. The stratabound breccias probably formed by intense dextral bedding parallel shear and complex repeated echelon veining. The dominant dextral bedding parallel shear in the centre of the refold was induced by asymmetrical tightening of the refold's east limb.

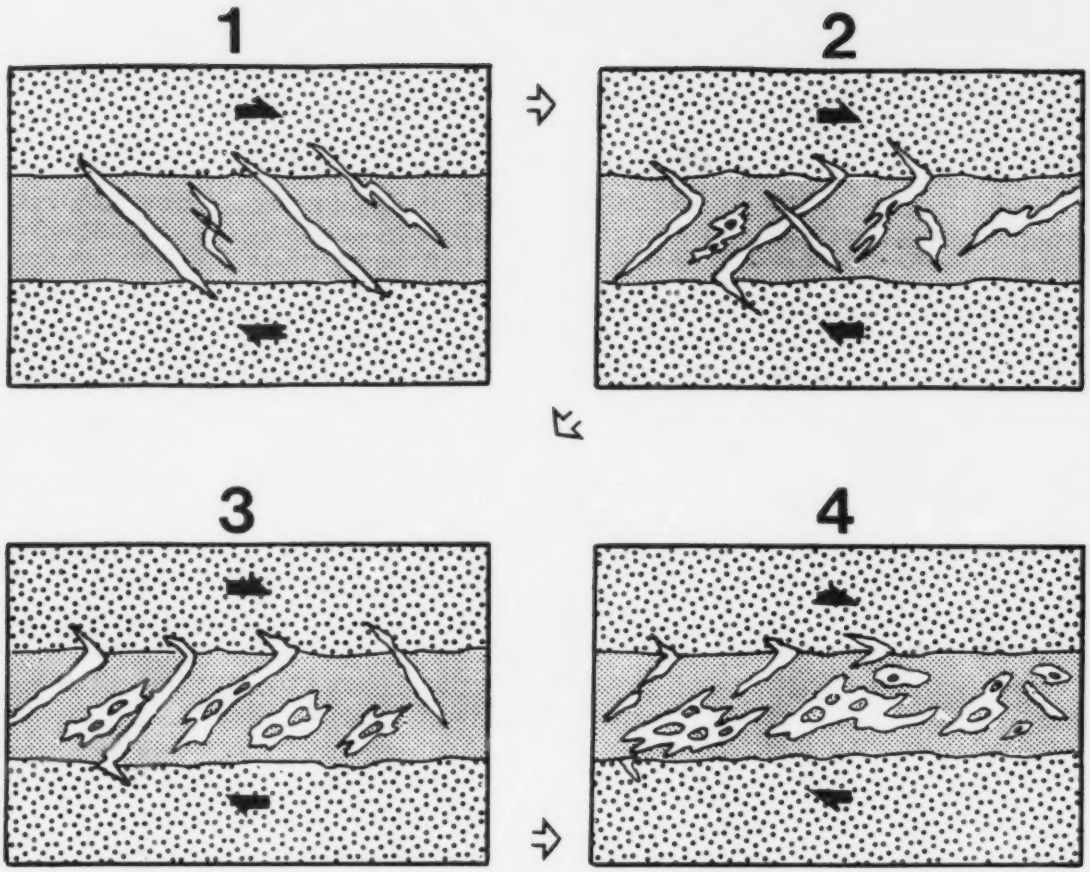

Figure 18. Structural mechanism for the formation of the Type III Stratabound Siltstone Hosted quartz-breccias (such as the Kidney pond Zone 1) . 1.) Echelon vein formation in siltstone beds during initiation of D4 dextral bedding parallel slip, minor S4 crenulation. 2.) Rotation of early echelon veins and formation of new cross-cutting echelon veins. 3.) Further dextral bedding parallel with initiation of brecciation and intense S4 crenulation. 4). Zones of compete brecciation with hinged vein tips along wacke/siltstone contact.

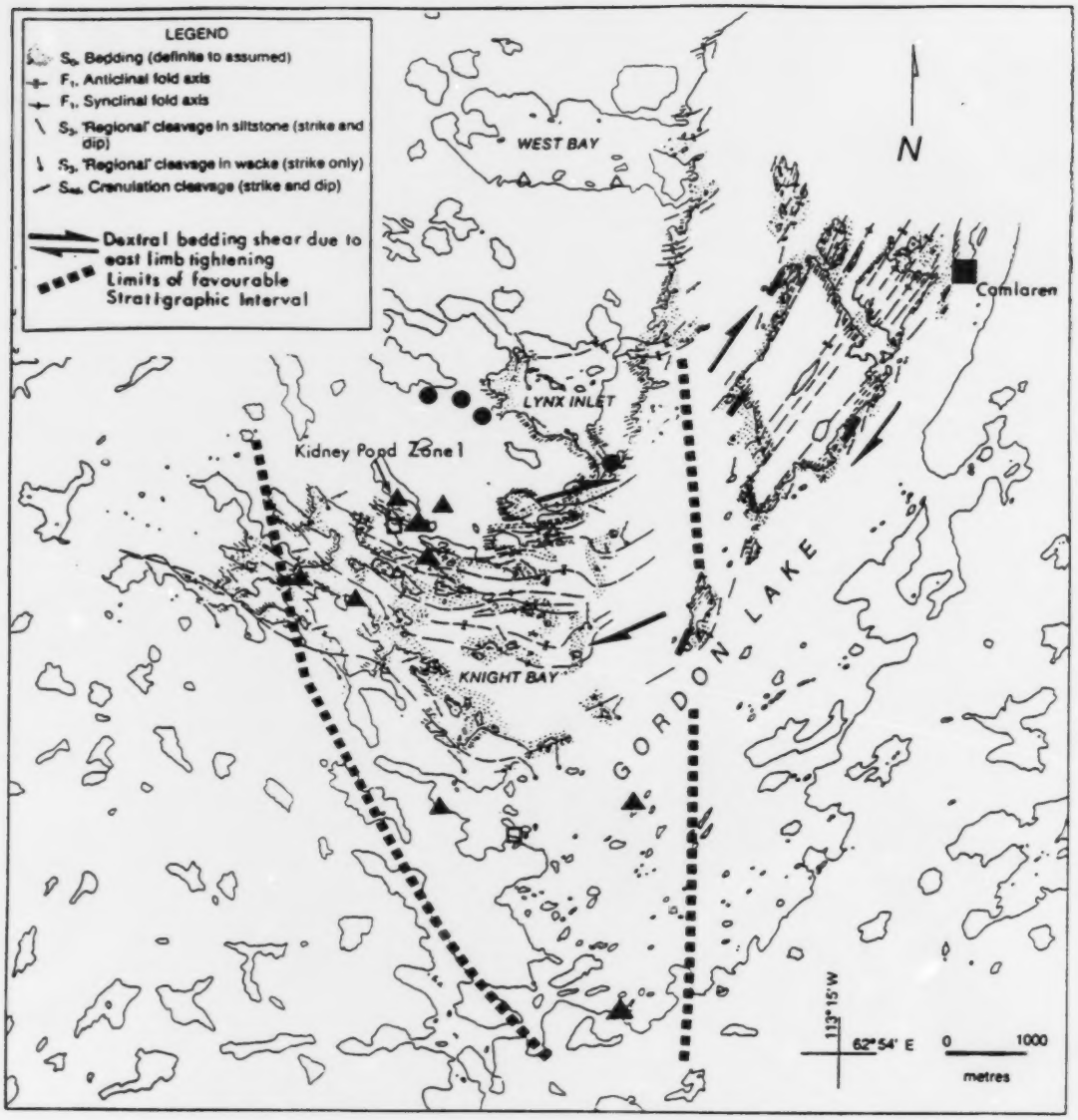

Figure 19. Refold asymmetrical tightening and associated dextral bedding parallel slip. Location of major breccia zones; filled triangles indicated Type III stratabound siltstone hosted breccias, filled circles Type IV wacke hosted breccias, open triangles Type II F3 related breccias, filled rectangles Type V East limb breccias and open squares Type I F1 related breccias.

7. SUGGESTED FIELD EXPLORATION CRITERIA FOR THE LOCATION OF FURTHER GOLD BEARING QUARTZ BRECCIA ZONES.

1. A lithology of thinly bedded, alternating siltstones and wackes is required for the formation of the stratabound breccias, and provide a target for regional exploration.

2. The presence of black carbonaceous siltstones appear important for bedding parallel slip and fracturing, as well as the possible chemical scavenging and concentration of gold.

3. Areas of vein offset across bedding and vein rotation might indicate regions of bedding parallel slip that are favourable for the location of stratabound breccias.

4. The formation of crenulation cleavage and rotation of the S3 wacke cleavage within refold structures are good indicators of late structural movement. Other refolds within the Yellowknife Basin might indicate a similar process of late deformation, and are hence favourable localities for late dilational and vein forming events.

5. Vein and host rock geochemistry appears important with respect to the Kidney Pond type breccias with their possibile associated thermal metamorphic high and (larger than might be expected) alteration halos.

8. RECOMMENDATIONS FOR FURTHER WORK

1. Field structural data would now be assisted by an internally consistent $^{39}Ar/^{40}Ar$ geochronological study using mica and hornblendes from breccia, metamorphic, volcanic and plutonic material. This would assist in confirming the deformational and mineralization events, and relating them to the regional tectonic evolution of the Slave Province and other possible mineralization events.

2. A pilot geochemical investigation of the Kidney pond breccia and the surrounding lithologies would determine: 1) whether the breccia zones are significantly richer in gold than other vein types, 2) the presence or absence of a significant geochemical halo around the breccia as suggested by Brophy (1986) and 3) the geochemistry of the black carbonaceous units and their relationship to the breccia zones.

3. Further field work, using this structural and lithologic model, might be applied to other parts of the Yellowknife Basin

for the location of similar areas of late fluid focussing veining and brecciation. Targets within the Yellowknife Basin might include other refold structures such as at Ross and Cleft Lakes.

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